Musical Notation & Representation

Music 253/CS 275a
Stanford University
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9 Jan 2018
Representing Music

• For **Performance** (used as memory aid and for non-aural transmission)
  
  Usually not a complete representation (some discretion left to performer)
  
  • Usually written, but also Guidonian hand is a spatial representation of music for education and memorization.

• For **Analysis**

  Usually highlights a specific aspect of the music (reductive)
  
  • Graphical representations (visualizations)
  • Digital representations (computational analysis)
  • Audio-based analysis (such as spectrograms)
Oldest Known Music Notation

Old Babylonian cuneiform musical notation. 2000-1700 BC

2 double columns, each of 7 ruled lines with numbers in Old Babylonian cuneiform tablature notation, with headings, "intonation" and "incantation", respectively.

Two ascending 7-note scales to be played on a 4-stringed lute tuned in ascending fifths.

http://www.schoyencollection.com/music_files/ms5105.jpg
http://www.schoyencollection.com/music.html
Music Notation in Ancient Greece

Oldest complete notated song (~1st century AD)

C ᾱΖ ξィ K I Z I
Ό σον ζής φαί νου

Κ I Z I ᾱΚ Ο C ᾱΦ
μη δὲν ὦ λως σὺ λυ ποῦ

C Κ Ζ ί ᾱΚ Κ Ε C ᾱΦ
πρὸς ὦ λί γον ἐς τί τὸ ζήν

C Κ O ᾱΖ ᾱΚ C ᾱC Ξ ι
τὸ τε λος ὦ χρό νος ἀπ αι τεῖ.

Music Notation in Ancient Greece

While you live, shine

Have no grief at all

Life exists only for a short while

And time demands its toll

Performed on a hydraulis: https://www.youtube.com/watch?v=P4_iWkP24Ww&t=7
Music Notation in Ancient Greece

2nd century BC
Earliest surviving composition with a known composer (Athenios son of Athenios)


3rd century AD

http://en.wikipedia.org/wiki/Oxyrhynchus_hymn

Tonic Sol-Fa

The Lamb.

William Blake.

http://en.wikipedia.org/wiki/Tonic_sol-fa

Guidonian Hand in action (Bill Mahrt, Stanford):

https://www.youtube.com/watch?v=RlleweQuq14
Byzantine Music Notation

(10th – 15th centuries)

Romania, 1823

http://en.wikipedia.org/wiki/Musical_notation#Byzantine_Empire

http://www.musicportal.gr/byzantine_music_system/?lang=en
Gregorian Chant

http://ww.schoyencollection.com/music_files/ms1681.jpg

Messine notation
Modern chant notation
St. Gall notation

http://euouae.com/category/transcription/

http://en.wikipedia.org/wiki/Gregorian_chant
http://en.wikipedia.org/wiki/Neume
Shape Notes

do re mi fa so la ti do

STAR IN THE EAST

Hail the blest morn, see the great Mediator.
Shepherds, go worship the babe in the manger.

Down from the regions of glory descend!
Lo, for his guard the bright angels attend.

Casius, Brightest and best of the sons of the morning!

Dawn on our darkness, and lend us thine aid!
Star in the east, the ho-ri-son adorning, Guide where our infant Re-deemer was laid.

1. Call on his cradle the dew-drops are shining.
   Love lies his bed, with the beasts of the stall.
   Angels adore him, in solemn reclining.
   Wise men and shepherds before him do fall.

   Brightest and best, &c.

2. Star, shall we visit him, in costly devotion,
   Obscure of Edom, and offerings divine.
   Genesis from the mountain, and peace from the ocean.
   Myrrh from the forest, and gold from the mine?

   Brightest and best, &c.

3. Vainly we offer each ample oblation,
   Vainly with gold we his favour secure.
   Either by far is the heart's adoration:
   Dearest to God are the prayers of the poor.

   Brightest and best, &c.
Tablature

Indicates how to play the pitches, not an abstracted/neutral concept of pitch.

http://en.wikipedia.org/wiki/Tablature

http://www.wikihow.com/Read-Guitar-Tabs
Steel Drum Tablature

— Jonathan Potter, Cardinal Calypso
Koto Tablature

Yamada school notation (Tokyo)

“Rokudan no shirabe”
by Kengyō Yatsuhashi (1614–1685)

Digital representation: by Kengyō Yatsuhashi (1614–1685)

https://www.youtube.com/watch?v=u26SG0015dc
Piano Tablature

Klavarskribo

“Keyboard script” in Esperanto

https://en.wikipedia.org/wiki/Klavarskribo

http://www.klavarskribo.nl/en

Cornelius Pot

https://www.youtube.com/watch?v=MloIvxunihA&t=659

http://evanlenz.net/blog/2007/11/02/re-discovering-klavarscribo/

http://en.wikipedia.org/wiki/Klavarskribo

http://www.klavarskribo.nl/en
Piano Rolls
Mechanical Representation of music

http://pianoroll.sapp.org/full-rolls-set2

http://en.wikipedia.org/wiki/Piano_roll

https://www.youtube.com/watch?v=GjpPesy7kIA
Music Animation Machine

http://www.musanim.com

Stephen Malinowski

https://www.youtube.com/channel/UC2zb5cQbLabj3U9l3tke1pg
https://www.youtube.com/playlist?list=PLMOarqHv8B7P1BuvL2iGqkjS1xNrvTiuX
Bach, Toccata and Fugue in D minor, organ
https://www.youtube.com/watch?v=ipzR9bhei_o

Mozart, Symphony No. 40 in G minor
https://www.youtube.com/watch?v=Vh-7NZbg65M

Beethoven, Fur Elise
https://www.youtube.com/watch?v=gD-OMO1pDNk

Beethoven, String Quartet No. 16, 1st mvt. (opus 135)
https://www.youtube.com/watch?v=Lj4kLPgX5QM

Paganini, Caprice No. 5 (solo violin)
https://www.youtube.com/watch?v=xhc1PsokFOw

 Debussy, First Arabesque
https://www.youtube.com/watch?v=Yt1jfX5C1u0

Vivaldi, Winter from Four Seasons
https://www.youtube.com/watch?v=Qqe0GdUpJHs

How are musical Dimensions mapped In each visualization?
Josquin Research Project

http://ribbon.humdrum.org
Performance Data Visualization

Webern Piano Variations, mvmt. 2, (Op. 27)

Anderszewski 1996

Gould 1954

http://dl.acm.org/citation.cfm?id=2597179

http://mazurka.org.uk/webern/notation/Anderszewski1996

Textural Notation

Analytic notation of electro-acoustic music

line2sine
Sonification of vector graphics
http://sig.sapp.org/projects/all;line2sine;/line2sine/examples

Example 6:

See the music of Iannis Xenakis
http://en.wikipedia.org/wiki/Iannis_Xenakis
Schenkerian Graphs

Edgard Varèse
Pitch reductions for Hyperprism

mm. 1 3 5 12 15 19 23 27 30 32 34 37 39 44 48 50 53 59 68 72 84 85

http://en.wikipedia.org/wiki/Hyperprism_%28Var%C3%A8se%29
GTMM

Constituency-based parse tree

John hit the ball.

http://en.wikipedia.org/wiki/Parse_tree

Keyscapes
Graphical display of harmonic structure

Chopin mazurka in A minor Op. 67, No. 4
https://www.youtube.com/watch?v=AcxZRI6aews

A major: 1:18
A minor: 2:10

Scape plotting domain:

background
large-scale structures
middleground
small-scale structures
foreground
surface features

An Orchard c1896 Henri Rousseau
Computational Key Identification

http://extras.humdrum.org/man/keycor
Computational Key Identification

Pearson correlation: \[ r(x,y) = \frac{\sum_{n}(x_n - \bar{x})(y_n - \bar{y})}{\sqrt{\sum_{n}(x_n - \bar{x})^2 \sum_{n}(y_n - \bar{y})^2}} \]

Krumhansl-Schmuckler key-finding algorithm: \[ \text{key}_k = \arg \max_k r(x,y_k) \]

http://extras.humdrum.org/man/keycor
Computational Key Identification

```
<table>
<thead>
<tr>
<th>Pitch-Class Counts (Duration Weighted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C: 8</td>
</tr>
<tr>
<td>C#: 0</td>
</tr>
<tr>
<td>D: 0</td>
</tr>
</tbody>
</table>
```

**Diagram:**
- **Major Keys:**
- **Minor Key Correlations:**
  - Best fit: $r = 0.79$ (F minor)

**Pitch-Class Histogram:**
- $x = (8, 0, 0, 0, 2, 11, 0, 5, 7, 0, 5, 2)$
- Major Key Prototype: $y_M = (2, 0, 1, 0, 1, 1, 0, 2, 0, 1, 0, 1)$
- Minor Key Prototype: $y_m = (2, 0, 1, 1, 0, 1, 2, 1, 0, 1, 0, 0)$
Beethoven Piano Sonata #5 mvmt 1
Other C-Minor BeethovenSonatas

No. 5:

Piano Sonata no. 8 in C minor, op. 13 ("Pathétique")

piano sonata no. 32
Form Visualization/Analysis

http://www.bewitched.com/song.html

Martin Wattenberg

Infinite Jukebox


Paul Lamere
Similarity Matrix

Jonathan Foote


J.S. Bach WTC 1: Prelude #1 in C major